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KPIs FOR TRANSITIONING TO KNOWLEDGE ECONOMY

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Abstract:
In this paper, we propose to fill gaps related to Knowledge Economy Key Performance Indicators (KPIs) usually considered in the literature, in particular, in well-known reports as the Global Innovation Index and the corresponding pillars categorized in the publications of the World Bank. We present the requirements that necessitated that complementation work and we initiate a system model to automate the feedback of information related to KPIs that report, usefully and significantly, on transitions and on the implementation of public policies promoting R&D, innovation and knowledge economy.

Keywords :(R&D, Innovation, Indicators, Economy, Value)
JEL Classification Codes: O380 Technological Change: Government Policy

1- Introduction

The knowledge economy makes a significant difference in terms of the organization of public and private institutions and on the wealth creation to the point of visibly seeing growth in the countries and regions where this economy is matured (Joonghae2007), (PMO-Singapore2020), (DF-Canada2017) and (DG-DF-EUROPEAN COMMISSION2023). It

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is an economy where knowledge is the most determining resource for related outcomes. Then, intangible assets, the intellectual capital, and their management are the most important factors for this performance and sustainability.

Indeed, reference (Sira2020) states that improving the knowledge economy based factors progresses the growth of competitiveness and then the related economic performance sustainability. Reference (Bilimleri2017) presents an extended summary of diverse references highlighting the importance of knowledge economy. It shows that knowledge investments increase the returns and, in the long term, it impacts significantly the economic growth. However, to reach this development level, effective and coherent planning and implementation at both strategic and execution levels are of utmost importance. It remains that the best way to do this is still a matter of a complicated debate (Fenwick2011).

The literature on this matter is diverse and widespread. Examples of successful corresponding experiences are numerous. The cited references (Joonghae2007), (PMO-Singapore2020), (DF-Canada2017), and (DG-DF-EUROPEAN COMMISSION2023) are related to such experiences rich in lessons. A special attention should be drawn to reference (Fillion2024) in which the practices of evaluating public innovation policies are studied and where it is demonstrated that governments do not have effective frameworks to measure the return on investment (RoI) of incentives for innovation. According to this reference, in most cases, the effectiveness of the frameworks is not evaluated according to the results of the implemented policies. Indeed, this is visibly noticeable with the low adherence of developing country industries to R&D and Innovation policies.

In this perspective, when examining the literature dealing with knowledge economy related KPIs, notably in (Dutta2024) and (Chen2005), there is a consensus on some factors related to education, R&D, innovation, and high-tech products, but there is no direct strategy related KPIs neither in the Global Innovation Index reports (Dutta2024) nor in the four pillars of the knowledge economy (Chen2005): in these references, Strategy KPIs could be inferred but they are not explicitly listed. This lack is particularly critical, for developing countries, when transitioning to knowledge economy. It is precisely in this sense that we

propose to fill gaps and make the monitoring and evaluation of this transition's KPIs automated and straightforward.

The next section presents issues in actual traditional as well as in knowledge economic value creations. Knowing those issues, we mark out some requirements and we propose new KPIs' categories to not lose sight when transitioning to knowledge economy. More, we formulate a model for, effectively and usefully, tracking knowledge economy KPIs. Then, we conclude with a summary of our contribution advantages and an open synthesis depicting the immediate extension of this work.

Note: In this paper, an "Entity" means a node of the hierarchical tree that is being monitored or evaluated for transitioning from a traditional economy to a knowledge economy related system. It could be a country, a sector of activity, a company, a department or other nodes like a region, a continent or any entity interesting for monitoring and evaluation.

2- Economic value creation

Debate on economic value creation is not that abundant. However, high-ranking intellectuals depict deep questions and analysis about this matter and layout options to let the economy regain its senses. Among those thinkers, Omar Aktouf in reference (Aktouf2021), Mariana Mazzucato in (Mazzucato2020) and Clayton M. Christensen and Al in (Christensen2020) are cited in the following sub-section.

Similarly, knowledge economy and especially transiting to knowledge economy would follow the traditional economy value creation drift unless its monitoring and evaluation are reformed.

2-1. Issues in value creation in the traditional economy.

Reference (Aktouf2021) calls the related drift a "failure of meaning" in the modern economy with a loss of values (especially) of quality of life. Reference (Mazzucato2020) explains from where does wealth come from and actually where is it lost. It shows that economists have lost sight of what value means and why we need to rethink the whole global financial system. It takes up real stories from history to conclude with the necessity of clearly discriminate the economic value creation from its extraction, which could be sterile or, worse, harmful.

Reference (Christensen2020) explains that according to the existing, and non-adequate, metrics and tools that guide investments, creating "real" economic value for long-term prosperity is the wrong thing to do for investors. Those existing tools are based on wrong assumption considering that capital is not that available, and that performance should be assessed by financial efficiency only. The authors show that the truth is that capital is not scarce and the exclusive financial efficiency do not lead to economic growth and value creation. So, those metrics and tools need to catch up with what is really beneficial for countries and for humanity.

The three references cited in this section call for long-termism as suppose to the current short-termism that is all about quick financial returns. Actually, they take up the sense of economy with its ethical, social and environmental dimensions.

2-2. Issues in value creation in the knowledge economy.

As presented in the introduction, the value in knowledge economy comes from activities where knowledge, intellectual capital and intangible assets constitute the most important resources. Mostly, this refers to education, R&D and Innovation, Information and related infrastructure and conductive economic and institutional regime (Chen2005).

Like for the traditional economy, economists do not dive into questions that highlight the effective value creation, the value extraction and the real value beneficiaries. More, there seem to be confusion between, the intrinsic, the resultant and the perceived values of the knowledge economy. Reference (Sira2020) touch to that problem by dividing knowledge economy indicators on two categories: one is about the basic characteristics of the Knowledge economy itself like employment in high-tech industry, innovation and high education, the second is about the performance or the outputs of that economy including production of high-tech industries, high tech exports, GDP, labour productivity and so. Reference (Sira2020) does not focus on the usefulness of this categorization. Rather, it deals with other considerations. We find it, though, very useful. Actually, we should deeply elaborate on them, set more categories, show more correlations between KPIs and trace them to

clarify their effective impact and eventually act on them to correct the way to go to achieve determined objectives.

Actually, to determine value creation, value extraction and value perception in a clear strategic framework, the following gaps should be filled:

- Lack of direct strategy-related KPIs. It is very frequent to find references talking about strategies. However, when checking the presented indicators, related measurable KPIs are very rare. For instance, the four pillars of reference (Chen2005) indirectly infer the necessity of having a strategy. We think that the question of whether an entity (at a country or other levels) has an effective knowledge economy strategy and whether this one is communicated and executed, should not be inferred, it should be watched with pertinent and direct KPIs.
- Unclear discrimination between inputs specific to the knowledge economy and those of the traditional economy. For example, "high-tech exports" is a KPI used for assessments of the knowledge economy (Chen2005) and for innovation (Dutta2024). However, every component of high-tech exports is not fundamentally a component of the knowledge economy. Some countries sell high-tech products while the associated R&D and knowledge-intensive activities are carried out elsewhere. These countries' value chains are almost entirely made up of manufactured and commercial products that are not the essence of the knowledge economy.
- Lack of specific KPIs that take into account the specificity of the context, whether it is related to the geography, the available resources, the development stage – transitioning towards knowledge economy or improve a context of well-established knowledge economy. In Reference (Sira2020) analytical methods are presented to assess or to transition to knowledge economy in order to ensure the country's sustainable competitiveness. However, the method is presented for all EU countries while priorities are not the same for all of them.
- Lack of coherence between KPIs. While several different KPIs are always used, it is very important to wisely choose what to measure and how the whole does make sense for an effective evaluation. Some KPIs are correlated and some are not. There is a

need to have models where one can weight or even eliminate indicators adequately to highlight specific information.

3- Proposed requirements for monitoring the transition to knowledge economy

Any proposed solution to set up a KPI reporting system would be imperfect. So, in some cases the option would be to fine tune a set of particular requirements for particular objectives, and in other cases, design a generic system that could enlarge as much and as diversified objectives as possible. Feeding back KPIs to trace and analyze a knowledge economy would require a framework that copes with different levels (entities) of analysis and respond to specific needs. This paper is laying out a ground to comply with the following requirements:

- These KPIs are traceable at every level that impacts the most global ones: at the regional level, at the country, at the sectorial, at the company level and at the départements; mainly at the R&D and innovation levels.
- The related framework should be logical and provides data to different dashboards as needed.
- KPIs are modulated by weights to match the needed analysis context.
- The KPIs' feedback model should be agile and could be adapted as needed. If an analyst wants to focus on a phenomenon; like an activity or a single technology or a single product, the model could be adapted accordingly.
- The framework should be revealing the determination and the effort to go towards knowledge economy and/or sustain its evolution.
- The traceability should be set automatic. Actually, it needs a math model that considers these above requirements and that allows the cited genericity.
- It should favor early participants in the creation and the development of the knowledge economy and particularly the early users of R&D and Innovation. The framework should encourage and do justice to the organizations which are in the dynamic of starting up and supporting knowledge economy. That is particularly useful in

developing countries where R&D and innovation are not launched even in big companies.

- It should discriminate between knowledge economy intrinsic indicators and the traditional economy indicators.
- Well set correlations in the aim of creating value. In some cases, an indicator could be a decisive lever; for instance, according to (Sira2020) “the aim of the EU 2020 in knowledge and innovation is to reach the expenditures on R&D as 3% of gross domestic product”. However, as shown above, most likely, spending more towards a determined ratio is not necessary a factor for value creation. So, because individual KPIs are not sufficient, elaborated formulas should combine different KPIs to work towards determined strategic objectives.

4- Proposed KPI categories for more effectiveness in monitoring and evaluating transitions to knowledge economy

Some Knowledge economy KPI indicators are well known. The World Bank categorizes them in four pillars (Chen2005):

- Educated and Skilled Labor Force,
- An Effective Innovation System,
- An Adequate Information Infrastructure,
- A Conductive Economic and Institutional Regime.

Reference (Sira2020) gives a kind of status on the published knowledge economy Indicators. More, it divides them in two categories: one is about the basic characteristics of the Knowledge economy itself, the second is about the performance or the outputs of that economy. That helps discriminate the knowledge economy intrinsic indicators from the related outcomes. As mentioned above, evaluations and ranking might be distorted because of the confusion between those two categories.

In our knowledge, none of those categorizations presents direct KPIs for strategy. These later might be inferred from indirect indicators but that is not what is needed particularly when transitioning from a traditional economy to a knowledge economy.

In this section, we are proposing KPIs categories that show the performance of an entity in setting up and executing a strategy and we give an example of a KPI that tracks efforts to implement a strategic goal: This is an indicator linked to the objective of controlling the value chain.

4-1. Proposed tree structure of a strategy related KPIs

Because documenting and communicating strategies, necessarily, contributes to the alignment of efforts and achievements with the targeted objectives, the proposed KPIs concern the definition, the implementation and the monitoring of the strategy execution. Indeed, the well-known references (Dutta2024), (Chen2005) and other Knowledge economy related reports could add adequately the following three categories of KPIs:

- KPIs for the Strategy Elaboration.
- KPIs for the Strategy Execution.
- Cross-checking KPIs for objectives set and achieved.

For a proper contextualization of the above proposed indicators, we set them in a tree structure with other indicators that may already be used in the literature.

4-1-1. KPIs for strategy elaboration

For the strategy definition:

- The Strategy is formulated and documented,
- Existence of market and technology assessments and estimates,
- Objectives are clearly defined, prioritized, and documented,
- The entity's management has conducted an adequate analysis to construct the estimated phases of the strategy,
- The entity's management aligns its strategy with that of the hierarchically superior and subordinate entities.

For the allocation of resources to meet strategic objectives:

- Roadmaps/programs have been built to achieve prioritized objectives,
- Adequate resources (human, financial, technological) are allocated to achieve these objectives,
- Alternatives are established to address risks related to resources.

For the strategy communication

- The strategy has been adequately communicated to all stakeholders,
- The stakeholders understanding of the strategy,
- The stakeholders' responsiveness to the communicated strategy.

4-1-2. KPIs for strategy execution

For strategy implementation

- Plans / roadmaps are projected and documented,
- Alignment between quality management processes and strategic options,
- IT infrastructure, platforms and tools effectively support and help achieve strategic objectives.

For skills and training

- The needed skills and competencies have been identified,
- Training and/or competencies procurement programs have been implemented to execute the strategy.

For the alignment of the management system with the strategy

- The management system is implemented and aligns with the strategy,
- The processes are designed to achieve the strategic objectives,
- Performance Indicators (KPI) are established, are reported and are adequately monitored by the management staff.

4-1-3. Cross-checking KPIs for objectives set and achieved

- Indications on the feedback reporting of execution results in relatively real time,
- Indications that these results are adequately edited on hierarchical dashboards for all necessary stakeholders,
- Indications on the alignment-checks between these results and the formulated strategic objectives.

4-2. KPIs for the internalization of links in the value chain of tech product development

At the operational level usual KPIs are numerous. However, for transitioning from a traditional economy to a knowledge based one, one needs to set KPIs that go with that transition; basically, considering that knowledge is essential. Among other KPIs, indications on the internalization of links in the development value chain is, without a doubt, a revealing one.

So, in an organization, in addition to the number of proposed ideas internally for new products or the number of proposed ideas externally to implement open innovations or co-developments, one should consider the trend towards improving in-house capabilities; the internalization of procured products or modules for in-house development or an open development where the knowledge and the value chain is gradually and resolutely well controlled.

This category of KPIs may not be used in all analysis and evaluations, but it will be very useful wherever the move towards knowledge economy is monitored: Moving from procuring finished tech-modules or products to developing them should show clearly.

5- A proposed model for setting and tracking knowledge economy KPIs

An individual KPI for an individual entity is a value. Depending on the needed analysis, it can be combined with other KPIs and results in an indication with the same nature of value. Or, it can be combined with other KPIs to indicate ratios or a completely different nature of value and meaning. For example, the “Expenditure on open innovation vs. in-house

development" can be utilized in R&D expenditure analysis and be inserted in combined KPIs that keep the nature of amounts of money. And it can contribute in other analysis that deal with in-house capabilities and value chain's control where it ends up with levels of readdresses and capabilities that are not amounts of money. To feedback information and KPI from the lowest levels of execution (at departments) to the highest ones (at the global level), one needs processes and a formula to express the needed KPIs combinations. While processes should be specific for the type of needed analysis, the formula could be generic. That is what we are proposing in this section.

In the context of this paper, we cannot be exhaustive, but we are showing a simple tree structure going from a global indicator to its company and departmental corresponding indicators (**Figure N° 1**).

The model can be formulated as follows:

$K_{result} = \sum_{i=1}^{n} Ke_i * We_i * (1+Te_i)$

Where

$Ke_i = \sum_{j=1}^{m} Kp_{ij} * Wp_{ij} * (1+ Tp_{ij})$

K_{result} is a combined KPI for a single top-level characteristic. It is made up of all the KPIs that impact it.

n is the number of considered entities (global, country, sector, company, department). One could add regional or continental or any needed entity.

m is the number of KPI for an entity.

i is the index of the considered entity.

j is the index of individual KPI (of an individual component).

Ke_i is the composed KPI for an entity.

Kp_j is and individual KPI (an individual component) which is meant to be composed to constitute Kei .

We_i, **Wp_j** are weighting factors. They would allow to weight and put values into perspective according to the type of monitoring or analysis. When needed, it could set a relative importance between KPIs.

Te_i, **Tp_j** are numbers of time units that increment from the activation of corresponding KPIs. It is recommended to let them be in the interval of [0:1[. For example, if a month is considered in a period of 12 months, the unit of time would be '1/12'. They can be canceled if not needed.

Nevertheless, they could be very useful for transitions to knowledge economy and to R&D&I based systems, as they take into account the precedence (over time) of adherence to policies that go towards knowledge economy.

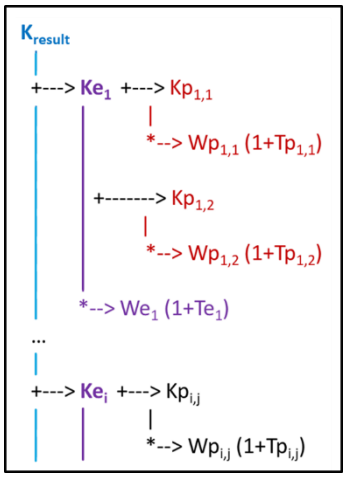
A dedicated use of the weighting parameters and their combination with time factors allows for different reporting and dashboarding options.

Because those KPIs can constitute well elaborated Dataset, their categorization and weights could also be used for AI reporting systems.

Table N° 1 gives an example of global-level KPIs with their corresponding company and R&D department's ones.

In that table, the Weighting and Timing factors are masked to ease the illustration. Next to each of KPI value, there should be two columns for the Weighting and the Timing parameters respectively as shown in the formula above.

Figure N° 1: The beginning of a tree structure going from a global indicator to lower levels' ones



Source : (Created by the Authors)

6- Advantages of the proposed framework

The proposals for a KPI framework go beyond monitoring just the transition to knowledge economy. However, here we focus on the latter topic and especially to address the gaps mentioned above.

We can summarize the advantages of our proposals in three points:

1. Filling the listed gaps in section 3.2. We are proposing to set:

   - direct strategy-related KPIs and link them adequately to other impacting indicators,
   - modulated KPIs according to the context,
   - consistency between KPIs by using the weighing system and the time factor to highlight or conceal KPIs according to the needed analysis.

2. The proposed model helps the evaluation and measurements of public policies implementations because of:

   - the possibility of permanent monitoring of the related KPIs at every level of execution,
   - dedicated and rapid dashboarding using the weighing system,
   - smart use of KPIs. Decisions and especially incentives would be guided by the evolution of targeted KPIs. For example, many R&D and Innovation institutions ask to increase their subsidies even though they are not fulfilling the missions for which they were created.

3. distinguish between inputs specific to the knowledge economy and those of the general economy. Linking KPIs to all levels of abstraction of a product development would indicate the real performance at each link in the value chain as well as the performance of each stakeholder. For instance, in many cases what is called technology transfer through technology purchase is just wrong because by a detailed follow up as proposed in this paper, one may see that this kind of purchase does not provide a comprehensive knowledge of the used technology, but simply a learning of the used development tools. The advantage of doing this analysis would be, at least, to lead to considering the purchase of tools at their fair value, or better, the buyer of the technology could train engineers to learn the necessary development tools and plan, by other means, to learn more about the necessary technologies.

Table N° 1: Example of global-level KPIs with their corresponding company and R&D/Innovation department levels' ones

	Entity 1; i= 1		Entity 2; i= 2		Entity 3; i= 3		
KPI_{result}	**Global-Level KPIg**	**KPIg value**	**Company-Level KPIc**	**KPIc value**	**R&D and Innovation Department-Level KPIrd**	**KPIrd value**	
	Ke_1 = Total_Kg		**Ke_2 = Total_Kc**		**Ke_3 = Total_Krd**		
	Strategy Elaboration		Strategy definition		Strategy formulation and documentation		**$Kp_{i,1}$; j=1**
					Objectives definition and prioritization		**$Kp_{i,2}$; j=2**
					Strategy execution phasing		**$Kp_{i,3}$; j=3**
			Resources allocation		Roadmaps/programs		**$Kp_{i,4}$; j=4**
					Adequate resources (human, financial, technological) allocation		**$Kp_{i,5}$; j=5**
					Alternatives to address risks related to resources		**$Kp_{i,6}$; j=6**
			strategy communication		Strategy communication to all stakeholders		**$Kp_{i,7}$; j=7**
					Stakeholders understanding		**$Kp_{i,9}$; j=9**
					Stakeholders' responsiveness		**$Kp_{i,10}$; j=10**
			...		...		…
	R&D Expenditure		R&D expenditure as a percentage of total revenue		Utilization vs. allocation of the R&D budget		**$Kp_{i,1}$; j=1**
					Expenditure on product development vs. Technology development		**$Kp_{i,2}$; j=2**

	Entity 1; i= 1		Entity 2; i= 2		Entity 3; i= 3		
KPI_{result}	**Global-Level KPIg**	**KPIg value**	**Company-Level KPIc**	**KPIc value**	**R&D and Innovation Department-Level KPIrd**	**KPIrd value**	
					Expenditure on open innovation vs. in-house development		**$Kp_{i,3}$; j=3**
	…		…		…		…

Source : (Created by the Authors)

7- Conclusion

In this paper, we argue that well-known global reports on innovation and knowledge economy are indeed very useful. However, smart systems must be designed to take into account specific contexts and fill gaps, particularly for developing countries whose priorities, resources, and skills are very different from those of the countries ranked highest in these reports.

While fully adhering to a realistic long-termism and restoring decent senses to the economy, we propose setting up and monitoring indicators, especially, for entities (countries, companies and so) in transitions to knowledge economy. More, our proposed system model helps to automate needed and tailored feedbacks of related KPIs.

In addition to addressing the gaps listed in this paper, our proposed system would contribute to monitor and to evaluate the implementation of public policies, particularly those that legislate for transitions to knowledge economy.

The proposed new indicators and the system model in this paper are clear and generic. They can be adapted and used as needed. With this, we are engaged to (1) highlight more direct- strategy-based indicators and (2) to deepen the modelling of a framework where the correlations between KPIs are better expressed and where their containers could be shaped as datasets for AI analysis.

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